detected is inserted therethrough;

Fig. 31 is another perspective view of the non-contact position sensor of the tenth exemplary embodiment of this invention, depicting the state in which the object to be detected is inserted as viewed from a backside thereof;

Fig. 32 are expository illustrations showing operating states of the non-contact position sensor;

Fig. 33 is a graphic chart showing a relation of output voltage to moving distance of the object to be detected;

Fig. 34 is an exploded perspective view of a non-contact position sensor of the prior art;

Fig. 35 is a sectioned side view of the non-contact position sensor of the prior art; and

Fig. 36(a) and (b) are schematic illustrations of magnetic shutter of the non-contact position sensor of the prior art, depicting magnetized states thereof.

Figs. 37(a) and (b) illustrate fan-shaped and I-shaped shafts, respectively.

THE BEST MODES FOR CARRYING OUT THE INVENTION

First Exemplary Embodiment

A non-contact position sensor of a first exemplary embodiment of this invention will be described hereinafter with reference to the accompanying drawings.

Fig. 1 is a plan view of the non-contact position sensor in a state that a cover and a circuit board are removed in this first exemplary embodiment of the invention, and Fig. 2 is a sectioned side view of the same non-contact position sensor.

In Fig. 1 and Fig. 2, an L-shaped first magnetic body 24 is in contact to an N-pole 22 of a magnet 21. An L-shaped second magnetic body 25 is in contact to an S-pole 23 of the magnet 21. As shown, the magnet 21 is held at both sides between the first magnetic body 24 and the second magnetic body 25. A magnetic sensor element 26 is fixed to a tip end 24a of the L-shaped configuration of the first magnetic body 24 in a manner to face a tip end 25a of the L-shaped configuration of the second magnetic body 25. A hall element is an example that may be used as the magnetic sensor element 26. A magneto-resistance effect element (MR element) and a great magneto-resistance effect element (GMR and/or CMR element) may also be used as the magnetic sensor elements 26, besides the hall element. Although these magneto-resistance effect elements

to be detected is inserted in the aperture of the non-contact position sensor of the first exemplary embodiment. As shown, the largest feature of the non-contact position sensor of this invention is to directly measure angle, location, and the like by directly inserting the object being detected.

In Fig. 3, the rotary shaft 33 is inserted in the aperture 29a of the case 29, and a sectorial portion 34 having a fan-shaped section also shown in Fig. 37(a) provided at a distal end of the rotary shaft 33 is positioned between the tip end 24a of the magnetic body 24 and the tip end 25a of the magnetic body 25.

The sectoral portion 34 rotates as the rotary shaft 33 rotates. This rotation changes density of magnetic flux present in a gap formed between the tip end 24a and the tip end 25a.

That is, when a rotating angle of the sectorial portion 34 on the rotary shaft 33 shown in Fig. 4(a) is assumed to be 0 degree, the magnetic flux density is approx. 0.15T, as shown in Fig. 5. However, the magnetic flux density becomes approx. 0.32T, as shown in Fig. 5, when the rotating angle is 90 degrees as shown in Fig. 4(b).

In this exemplary embodiment, density of the magnetic flux between the tip end 24a and another tip end 25a increases as they become closer to the magnet 21, because the tip end 24a and the tip end 25a are slanted with respect to an N-S polar axis of the magnet. On the other hand, a speed of change in volume of the sectorial portion 34 occupying within the space between the tip end 24a and the tip end 25a decreases, as the rotating angle of the rotary shaft 33 increases. Accordingly, this can improve a linearity of the magnetic flux density that passes through the magnetic sensor element 26, responsive to the rotating angle of the rotary shaft 33 at the confronting side.

It detects a change in density of the magnetic flux as an output signal with the magnetic sensor element 26, converts it into an output voltage in the processing circuit 28, and outputs it through the connector terminal 31 to a computer, or the like, to measure a rotating angle of the rotary shaft 33.

In the first exemplary embodiment of this invention, as described, the structure is such that the rotary shaft 33 is positioned within the gap formed between the tip end 24a and the tip end 25a, to allow the rotary shaft 33 cause changes in density of the magnetic flux produced in the gap formed between the tip ends 24a and 25a in response to the rotating angle. This allows measurement of rotating angle of the rotary shaft 33 easily without providing complicated members such as a magnetic flux shutter and the like of the prior art.

object to be detected is inserted into the aperture 49a in the non-contact position sensor of this second exemplary embodiment.

In Fig. 8, one end of the rotary shaft 53 is positioned within a space formed among one tip end 44a, the other tip end 44b, and the N-pole of the magnet 41. A portion of the rotary shaft 53 located within the sensor is I-shaped in cross section also shown in Fig. 37(b). In this exemplary embodiment, density of the magnetic flux produced in the space formed between the tip end 44a of the magnetic body 44 and the N-pole of the magnet 41 changes responsive to rotation of the I-shaped portion 54.

That is, when rotating angle of the I-shaped portion 54 shown in Fig. 9(a) is assumed to be 0 degree, the magnetic flux density is approx. 0.15T, as shown in Fig. 10, whereas the magnetic flux density becomes approx. 0.4T, as shown in Fig. 10, when the rotating angle is 45 degrees as shown in Fig. 9(b). Further, the magnetic flux density becomes approx. 0.67T, as shown in Fig. 10, at the rotating angle of 90 degrees as shown in Fig. 9(c).

In this second exemplary embodiment, a portion of the rotary shaft 53 located in the space formed between the tip end 44a and the N-poles of the magnet 41 is I-shaped. Because of the above, the rotary shaft 53 is not present in the vicinity of the tip end 44b when two longitudinal sides of the I-shaped portion 54 are located in the vicinity of the magnet 41 and the other tip end 44a. On the other hand, the rotary shaft 53 is not present in the vicinity of the other tip end 44a when the two longitudinal sides of the I-shaped portion 54 are located in the vicinity of the magnet 41 and the tip end 44b. Linearity of the magnetic flux density that passes through the magnetic sensor element 45 corresponding to rotating angle of the rotary shaft 53 can be thus improved, since magnetism of the tip end 44b becomes weak when magnetism of the other tip end 44a becomes intense.

Accordingly, it detects a change in density of the magnetic flux as an output signal with the magnetic sensor element 45, converts the output signal into an output voltage in the processing circuit 47, and outputs it through the connector terminal 51 to a computer, or the like, to measure a rotating angle of the rotary shaft 53 at the confronting side.

In the foregoing second exemplary embodiment, the structure is such that the rotary shaft 53 is positioned within the space formed among the one tip end 44a, the other tip end 44b and N-pole of the magnet 41, to allow the rotary shaft 53 cause changes in density of the magnetic flux produced in the space in response to the rotating angle.